Reduction of Sewing Bottleneck Problem by Using Assembly Line Balancing
(CASE STUDY OF OCM TEXTILE COMPANY MADAGASCAR)

Lahatra TSIMAROFY PRISCA

***Abstract*— in the sector of production management techniques, operation management is one of the most effective tools for production floor management decision-making. The application of techniques is favorable to the solution of several complex problems associated with assembly management, scheduling which would otherwise be more difficult to solve. Assembly Line Balancing technique is one of the most effective operating management strategies for solving workload related problems and increasing production system. A case study on the allocation of workload and the related problem of bottleneck was carried out at Original Confection Mada (OCM) Textile Company in Madagascar. The experimental results indicated a significant improvement in productivity and line efficiency compared to the existing methods.**

***Index Terms*— line balancing, line efficiency, labor productivity, bottleneck**

I. INTRODUCTION

Over the past 150 years, garment structures have changed from the manual fitting and assembly of individual hand sewn garments to mechanized, automated and sometimes robotized for batch production.[1] Madagascar's textile and apparel industry are the largest formal employer outside of agriculture. It has the capacity to create hundreds of thousands of new jobs if the industry can regain U.S. buyer confidence and take advantage of duty-free exports to the U.S. through the African Growth and Opportunity Act (AGOA).The USAID East Africa Trade and Investment Hub helps Madagascar-based apparel companies to improve their efficiency and institutionalize the best practices and standards that American apparel companies require. The end result is formal employment for Malagasy workers and quality product for U.S. businesses.[2] The sewing stage is the most important and crucial stage among them. Sewing stages involves a lot of operations having a different cycle time to perform. In the traditional sewing line of garments, all of the workers are not equally expert to do all the process.[3] The implementation of operational management system is the first requirement for company to increase efficiency, minimize waste and maximize profits. From textile industry, Sewing is the most important task of making a garment or other similar product. It can be defined as the craft of fastening or attaching objects using stitches made with a needle and thread. It is a term used to describe the process used in factories to mass-produce a wide range of garments and other goods that are created by joining different components together along the course of a structured process. Sewing is done by putting parts together and joining into a whole garment.[4] The aim of this study is to solve the bottleneck problem of sewing line in a garment manufacturing company. The layout of the line was modified using the line balancing and time study technique.

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II. LITERATURE REVIEW:

A. Assembly Line:

An assembly line is the manufacturing process where in distinct tasks are assigned to a set of workstations and the parts are assembled into a product in a sequential manner. The set of workstations are linked together by a transport mechanism under detailed assembling sequences specifying how the assembling process flows from one station to another. Different operators carry out different operations in an assembly. An assembly line is advantageous as there is standardization in production, consistency in quality can be obtained, and there is a lot of scope of special machines, attachments, and work aids.[5]

B. Bottleneck Operation:

A bottleneck operation is that operation which holds up subsequent operations and possibly previous operations, as there is an accumulation of garments behind it. For example, situations like an insufficiency of a plant or labor, increasing throughput of one section, may create bottlenecks during production. This affects efficiency of the line, and labor productivity adversely. Ways to reduce WIP at bottlenecks are by improving method, sharing the capacity, using additional operator or machine, improving workstation layout, improve operator allocation.[6]

C. Capacity:

Capacity is the maximum amount of work that an organization is capable of completing in a given period. It is the theoretical maximum (or installed) capacity, with the assumption that operators are capable of working full 60 minutes per hour, which is practically not possible. Capacity depends on the availability of resources such as man, machine, time, space, and facilities that require capital investment by a firm.[7]

D. Daily Production Report:

The daily production report (DPR or PR) is one of the MIS tools for operation management used in the manufacturing industry. It shows the nature of the production floor and summarizes the reasons for the day's losses due to various reasons. DPR is made department wise as well as a combined report is made including the production of all major processes.[8]

E. Efficiency:

Efficiency is a way of representing the productivity in terms of how one is performing against a target expressed as time per garment or a required level of production. The efficiencies commonly assessed in a manufacturing unit are - Line efficiency, Factory Average efficiency, Operator efficiency. [9]

F. Lean Manufacturing:

Lean manufacturing is a way of manufacturing with the goals to reduce waste in human effort and inventory, reaching the market on time, and managing manufacturing stocks that are highly responsive to customer demand while producing quality products in the most efficient and in economical manner without waste. The types of wastes are waste from overproduction, waste of waiting time, transportation waste, inventory waste, processing waste, waste of motion, and waste from product defects. Some of the tools used for lean manufacturing are 5S, Kanban, Kaizen, Judoka, Poka-Yoke, Andon, Just-in- time, Gemba. [10]

G. Line (Production Line):

A line is defined as a group of operators under the control of one production supervisor. In the sewing line, a number of sewing machines (including different types of sewing machines and non-sewing equipment) are placed in a line according to the process sequence requirement. Sewing lines have different arrangement of the workstations. Garment bundles are loaded at one end of the line and moved from one workstation to another, and finally stitched garments come out from the line. There are multiple sewing lines in an apparel manufacturing unit.[11]

H. Line Balancing:

Line balancing is the technique of maintaining the same level of inventory at each operation at any point of time to meet the production target and to produce garments of acceptable quality. The work-study officer does line balancing by doing the product analysis, process analysis, and capacity analysis, and then allocating the available operators to the operations. The line balancing needs to be done such that target is fulfilled, priorities of operations are met, operators and machines are properly utilized, and the idle tie for operators is minimized. A well-balanced line has a smooth workflow, no bottlenecks are created, and the operators are able to work at peak performance throughout the day.[12]

I. Line Efficiency:

Line efficiency is the efficiency measurement for the sewing line. It is also termed as line utilization. Line efficiency is calculated based on the line output. It is expressed as percentage.[13]

J. Operation:

Tasks or activities involved in producing a garment are called operations. Operations could be sewing and non-sewing operations, or machining and non-machining. To produce a garment, number of such operations are involved, and each are connected to the preceding and succeeding operation. The work process contains separate operations depending on equipment available, equipment utilization, workers skills, and time available, such that quality and efficiency are ensured.[14]

K. Operation Bulletin

An operation bulletin is a summary document that includes the operation breakdown and more details. These are : total number of components in the garment, job code, machinery, work-aids, calculated number vs actual number of machines, work content of each operation, daily working hours, target output per day or per hour, SMV (Sewing and Non-sewing), SMV@100% efficiency, SMV @target efficiency, pieces per machine.[15]

L. Operator Performance

Operator performance is the measure of both skills and attitude of the operator. Operator performance plays a vital role in incentives calculation. It is calculated for individual operators and averaged for a line to evaluate the line leader or supervisor. To monitor the operator performance.[16]

M. Productivity:

Productivity refers to the amount of output obtained (production) per unit of input of resources. It is an efficiency measurement parameter to assess the extent to which a certain output can be extracted from a given input. [17]

N. Skill Matrix:

Skill Matrix is a chart or a database where operator's past performances on various operations are recorded in a systematic way for the future reference. The operator performance recorded here is as efficiency percentage. Skill matrix is also called as skill inventory of the operators. This matrix is very useful while allocating operators and balancing a line. Industrial engineers/line supervisors need minimum time to find and select most efficient operators for an operation from the pull of operators., and operators can be selected according to work content. It also aids when operation clubbing is required (for less work content works), skill matrix gives the information what all operation to be given to an operator. In case of an operator being absent, the supervisor can easily identify the most suitable replacement. [18]

O. Zero Defects:

Zero defect is a manufacturing strategy, where in the quality performance standard is to produce zero defective pieces by doing it right first time. The zero-defect approach is beneficial to achieve waste reductions and increase profits by eliminating cost of poor quality. The strategy suggests that the manufacturer change their perspective and realize the high cost of quality issues, monitor causes of defects, and proactively take improvement measures. [19]

P. Time Study:

Time study is a work measurement technique for recording the times and rates of working for the elements within specific conditions, and for analyzing the data so as to determine the time necessary for carrying out a job at a defined level of performance. Time obtained from time study is called cycle time.[20]

III. METHODOLOGY & EXPERIMENTAL WORK

III-A: METHODOLOGY:

Sewing is an important department in the textile industry. Most parts of a garment are joined by making stitches from sewing department. Our case study was taken from ORIGINAL CONFECTION MADA textile company in Madagascar. In order to balance the assembly line in the sewing floor, a line was chosen, and the necessary data was compiled from the line. Here researchers found that 12 different types of operations have been performed in the basic T-shirt product. There was a huge bottleneck in some process of the existing sewing assembly line. This bottleneck operation decreases the efficiency of the process. To improve performance, researchers minimized bottleneck operation from the sewing or production line using the line balancing process.

A. Bottleneck Analysis

A bottleneck is a point of blockage in a process or assembly lines that occurs when workloads arrive too quickly for the assembly process to handle. In this study researchers found few bottleneck points that they have solved by using line balancing technique.[21-24] To analyze the bottleneck problem we need to know about time study process, SMV measurement and sewing efficiency determination.

SMV formulas:

SMV = (Observe time x Rating Factor) + Allowance

B. Determination of Cycle time through Time study

Time study is most popular and used method for line balancing technique and to solve bottleneck problems. During this study researchers have faced major problem of time study which is the Hawthorne Effect. They found that employees change their behavior when they know that their being measured.[25]

C. Line Efficiency and Labor Productivity

Labor efficiency and labor productivity was estimated using the following formulas:

Efficiency Formulas:

$$Efficiency\% = \frac{\text{line output x Garment SMV}}{\text{Total. No. Operator x Minutes worked}} x\ 100$$

Labor Productivity formulas:

$$Labor\ Productivity = \frac{\text{line output per line per Day}}{\text{No. of Machines Used}}$$

III-B: EXPERIMENTAL WORK:

In order to balance the assembly line in the sewing floor, a line was selected, and the data collection was compiled from the line as shown in Figure-1. Here researchers find that 10 different types of operations have been executed in production line. There was a major bottleneck in some process of the existing sewing assembly line. This bottleneck operation reduces the efficiency of the process

Fig 1: Sewing line production with Bottleneck operation

IV. ANALYSIS OF EXISTING SEWING LAYOUT:

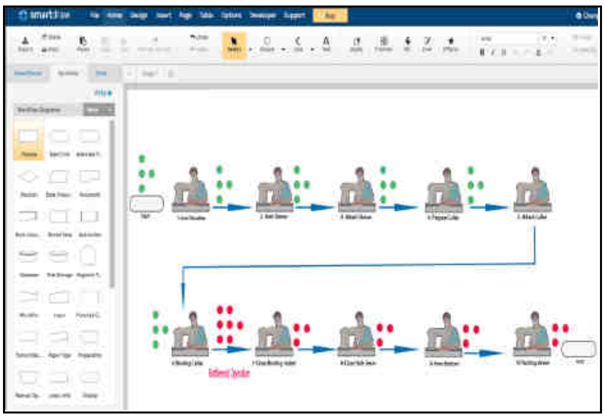

Fig 2: Existing layout of a T-Shirt sewing line

Researchers have found that three types of machines have been used in the existing sewing layout as shown in Figure 2.

The wise capacity of each workstation has been shown in Table-1.

SN	Process Name	M/C type	No. of m/c	SMV	Target /hour (PCS)	output/ hour (PCS)
1	Join Shoulder	O/L	1	0,3	200	160
2	Hem sleeve	F/L	1	0,25	240	160
3	Attach sleeve	O/L	1	0,4	150	140
4	Prepare Collar	SNLS	1	0,2	300	160
5	Attach collar	O/L	1	0,4	150	140
6	Binding Collar	F/L	1	0,3	200	140
7	Close Binding + Label	SNLS	1	0,61	98	80
8	Close side seam	O/L	1	0,5	120	80
9	Hem bottom	O/L	1	0,4	150	80
10	Tacking sleeve	SNLS	1	0,4	150	80
	Totals			3,76		80

Table 1: Operational bulletin of T-Shirt before Balancing.

Benchmark target per hour	**127 pcs**
Total manpower	**10 persons**
Working time	**480min**
SMV	**3,76 min**
Practical Output per Hour	**80 pcs**
Line Efficiency	**63%**
Labor Productivity	**8 pcs**
BOTTLENCK IDENTIFICATION	
Lowest capacity	**98pcs**
lowest output productivity	**80 pcs**
Trough Put time	**3,76 min**

Table 2: Production Recapitulation before line balancing

Table-1 shows the capacity of all operations by process, with Standard Allowed Minutes (SAM) calculated by taking the average cycle time for each process and taking into account in allowances. Table-2 shows the target per hour for the line, calculating a total of 10 manpower worked on that line for 480 minutes with a SAM value of 3.76 minutes. Researchers standardized the Benchmark target of 127 pieces of garment at 100% efficiency. Observation before balancing the line has been reflected as labor productivity is 8 pcs per operator per hour and, line efficiency is 63%.

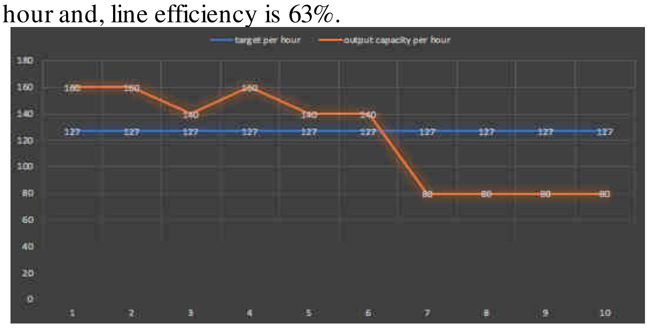

Fig 3: Process wise capacity variations (Before line Balancing)

Figure-3 shows the variation of each process from the benchmark target as the upper output is 127 pcs/hr. where the lower output is only 80 pieces per hour compare to the benchmark 127 pcs. This figure shows where the imbalance the line and bottleneck occur.

V. PROPOSED SEWING LAYOUT AFTER LINE BALANCING:

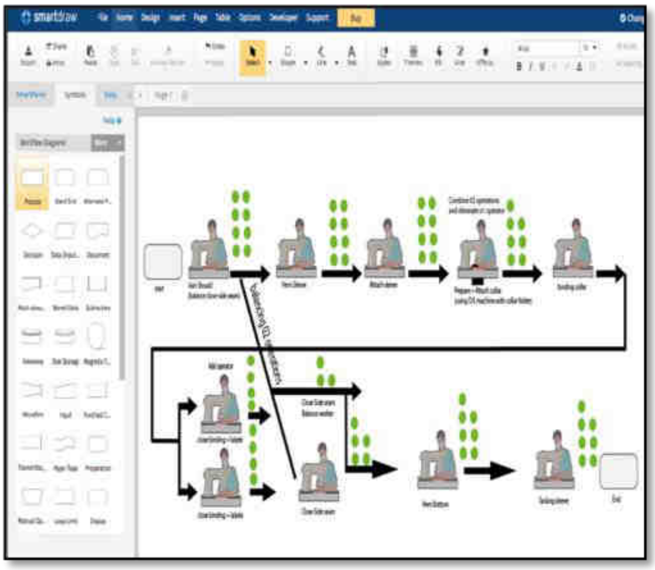

Fig 4: Proposed Sewing Layout

Researchers have found some variations in process capacity from the benchmark target in this study. The lower capacity from the benchmark target is the bottleneck point in the process so production flow will become stuck at the bottleneck point depicted in Figure-4. In such condition researchers have rearranged sewing line to meet benchmark target. Firstly, When the close side seam has an excess of production Work in Process, the Join Shoulder was balanced to help in the operation. Also, we combine the Prepare Collar and Attach Collar orders into one operation, but by using a special folder for the sewing machine, we can remove one extra operation. Finally, we know that the bottleneck was the close binding operation, and operator capacity was low. We added another operator to balance this operation and reach the production target output.

SN	Process Name	M/C type	No.of m/c	SMV	Target /hour (PCS)	output/hour(PCS)	line Balancing
1	Join Shoulder	O/L	0,5	0,3	200	160	balance 1+7
2	Hem Sleeve	F/L	1	0,25	240	160	
3	Attach Sleeve	O/L	1	0,4	150	140	
4	prepare + Attach Collar	O/L +folders	1	0,45	133	130	combine 4+5
5	Binding Collar	F/L	1	0,45	133	130	
6	Close Binding + label	SNLS	2	0,61	98	130	add operator
7	Close side seam	O/L	1,5	0,5	120	120	balance 1+7
8	Hem bottom	F/L	1	0,4	150	120	
9	Tacking Sleeve	SNLS	1	0,4	150	120	
	Totals			3,76		120	

Table 3: Operational bulletin of T-Shirt After Balancing.

Benchmark target per hour	127 pcs
Total manpower	10 persons
Working time	480min
SMV	3,76 min
Practical OutPut per Hour	120 pcs
Line Efficiency	94%
Labor Productivity	12pcs
BOTTLENCK IDENTIFICATION	
Lowest capacity (double worker)	98pcs
lowest out put productivity	120 pcs
Trough Put time	3,76 min

Table 4: Production Recapitulation after line balancing.

Researchers suggested adding one more sewing line in the close binding operation, combining the prepare collar and attach collar operations, and balancing the operation for join shoulder to help close side seam operator. After balancing and sharing workloads, the labor productivity is 120 pieces, and the line efficiency is 94%.

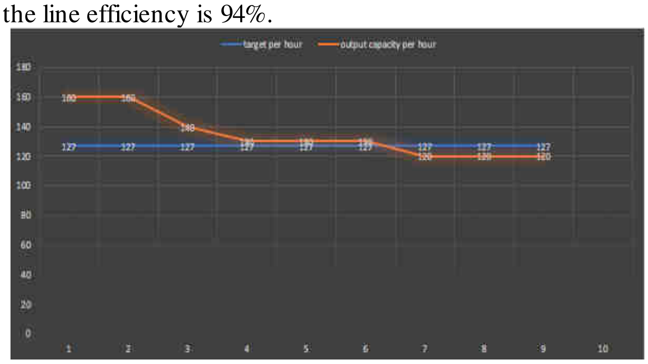

Fig 5: Process wise capacity variations (After line Balancing)

Figure-5 illustrates variation in each process capacity/hour compare to benchmark target improves after workload reallocation and line balancing. Proposed layout illustrates that the target capacity for each operation are above or very close to the benchmark capacity/hour. As a result, by employing the line balancing method, the bottleneck problem has been reduced.

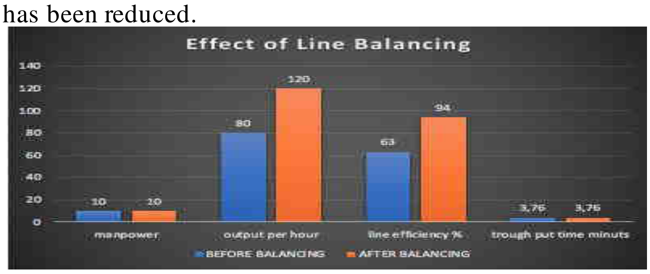

Fig 6: Significant Improvements

Figure-6 illustrates variation in each process output capacity/hour compare to benchmark target improves after workload reallocation and line balancing, with same number of manpower and same trough put time minutes. Proposed layout illustrates that the target capacity and efficiency for each operation are above or very close to the benchmark target capacity/hour. As a result, by using the line balancing method, the bottleneck problem has been minimized.

VI. Analysis of Functional Labor Flexibility

Researchers in this study suggested a new sewing layout in which the number of workers is the same as in Figure-6. Also, the time it takes to make one garment is the same: 3,76 minutes, but the output has increased from 80 to 120 pieces per hour. As a result, total output increased by 40 pcs/hour while labor costs stayed the same.

VII. Discussion

The efficiency of the sewing line has improved as a result of the precise positioning of machines, as demonstrated by this research. In the first scenario, 10 workers were employed, but efficiency was 63% and productivity was 80 pieces per hour. Close binding collar + label was the most time-consuming process, with a low production capacity. An optimal layout was proposed in the second scenario. The first bottleneck (close binding collar + label) and the second bottleneck (close side seam) processes were the most time consuming of the process. The workloads were well balanced in the proposed layout, and two more machines were added to reduce the bottleneck problem. Finally, 10 employees were applied, but their efficiency was 90 % and their productivity was 120 pieces per hour.

Conclusion

If researchers had analyzed two or more existing sewing layouts and balanced the process that is related to the same machines with similar operations, the results would have been more accurate. Two different layouts for a common process were shown in this study, and the efficiency of each process was measured. Researchers have attempted to demonstrate how an optimal layout can improve efficiency by reallocating workload and using a line balancing technique. It has also demonstrated how an optimal layout can make a similar process with relatively the same manpower more efficient.

Recommendations and Limitations

A cost analysis for each scenario can be added to this research. The proposed layout would be more validated, according to the researchers, if the simulation technique could be used. Multi-skilled workers can improve the efficiency of production processes, and proper operator training is required to achieve productivity and efficiency.

Conflicts of Interest

There are no conflicts of interest declared by the authors.

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Research Work: Operations management is one of the most powerful methods for production floor management decision making in type's production management techniques. The techniques can be used to solve a variety of complex problems related to assembly control and scheduling that would otherwise be difficult to solve. Assembly Line Balancing (ALB) is one of the most effective operations management techniques for resolving workload issues and improving line efficiency. At Original Confection Mada SARL, a case study on workload allocation and bottleneck problems was conducted. In comparison to the existing system, the experimental results show a large increase in productivity and line efficiency.